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Centipede communities in the forests of Flanders

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Summary

During a year-round pitfall sampling campaign in 56 Flemish forest stands, a total number of 21 centipede species were caught. Community analyses on the basis of the species composition revealed that three distinct clusters of forests could be recognised which are separated geographically. The Campine Region with a lot of pine forests, which is characterised by its sandy soils, contained the lowest diversity of centipedes and only *Lithobius forficatus* and *L. calcaratus* were common. Sandy Flanders with a lot of oak forests contained more species including *Cryptops hortensis*, the most characteristic species of this region. The Loamy Region contained a lot of oak and beech forests and *Cryptops parisi* and *Lithobius dentatus* were especially characteristic for this region.

Key words: Chilopoda, community analysis, Belgium

Introduction

Because forests in Flanders are highly fragmented and subjected to pollution due to agricultural and industrial practices, a study was started to evaluate the quality of forests by means of suitable bio-indicators. A focus was placed on those ground-dwelling arthropods which are dependent, during a certain stage in their life cycle, on fo-

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rest soils and belong to several different trophic levels (predators, saprophagous, xylophagous, …). The search for such bio-indicators (including centipedes) led to the sampling of 56 forest stands distributed over the whole region of Flanders (De Bakker et al. 2000).

Due to their strong dependence on moisture conditions in the environment, several years' long development cycle and the relative absence of food preferences in their predacious mode of life, centipedes form a relatively homogenous group from the ecological viewpoint (Lewis 1980). Despite their importance as invertebrate predators, especially in terms of biomass (Weidemann 1972; Wignarajah & Phillipson 1977; Albert 1979; Poser 1988; Schaefer 1990), centipedes have rarely been studied in detail. A review of the research on the Belgian centipedes for example, revealed that only a few faunistic studies have been published (Lock, submitted). In order to understand more about the ecology of centipedes, a lot more research has to be conducted. In the present study, the factors controlling the species composition of the Flemish forests were investigated.

Materials and Methods

Sampling

The 56 sampling plots were dispersed over Flanders (northern part of Belgium) (Fig. 1, Tab. 1). They represent a diversity of forest- and soil types which offer a great variation in habitats for invertebrates. The plots were selected among existing plots of (1) the forest vitality monitoring network, (2) the forest reserves and (3) some additional plots. Per station, 3 pitfall traps with a diameter of 9.5 cm were placed in a row, spaced 3 m apart. A 4 % formaldehyde solution was used for killing and fixation and some detergent was added to lower surface tension. During winter salt was added to prevent freezing. Pitfalls were emptied every two weeks and every three weeks during winter. Sampling lasted from March 1997 till May 1998.

Environmental variables

Topsoil horizons (Ah or Ap) were used for texture analysis. Soil texture was determined using laser diffraction equipment (Coulter LS 200) after drying and pretreatment with H_2O_2 (30 %)

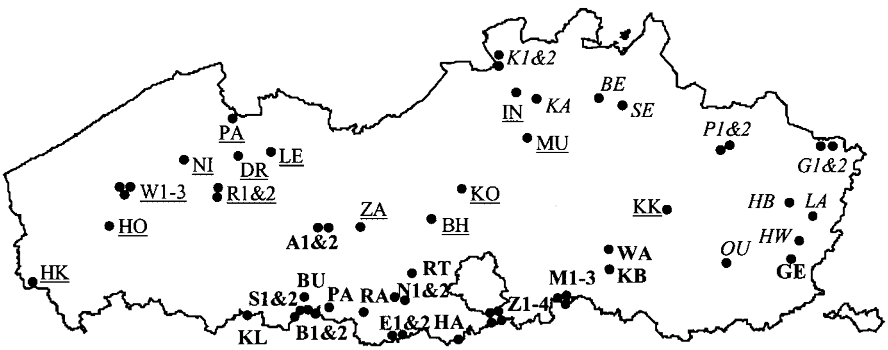

Fig. 1. Location of the sampling stations in Flanders with indication of the three clusters: Campine Region italics, Sandy Flanders underlined and Loamy Region bold

Table 1. List of the forests with indication of the used abbreviations, community, UTM-codes, clay content, humidity, Leaf Area Index (LAI), forest floor weight (FFW), pH-$CaCl_2$ and Kjeldahl nitrogen (N)

Abbr.	Forest	Community	UTM	clay (%)	H (%)	LAI	FFW (kg/m^2)	pH	N (%)
A1	Aelmoeseneie	Melle	ES5647	14,5	26,6	6,03	7,72	3,26	0,29
A2	Aelmoeseneie	Melle	ES5647	17,2	19,9	4,48	0,17	3,88	0,20
B1	Brakelbos	Brakel	ES5125	21,7	39,6	6,78	7,69	3,31	0,36
B2	Brakelbos	Brakel	ES5125	26,4	45,7	4,90	0,31	4,86	0,26
BE	Beerse Heide	Beerse	FS2883	3,6	9,2	2,51	9,29	3,43	0,14
BH	Buggenhoutbos	Buggenhout	ES8450	14,0	14,8	4,02	9,94	3,18	0,31
BU	Burreken	Brakel	ES4928	30,7	31,2	6,61	1,48	4,05	0,37
DR	Drongengoed	Knesselare	ES3166	19,2	17,0	3,36	8,42	3,63	0,16
E1	Bos Ter Rijst	Edingen	ES7619	24,3	29,5	5,38	0,63	3,76	0,52
E2	Bos Ter Rijst	Pepingen	ES7619	16,8	28,6	5,03	0,41	3,94	0,21
G1	Grootbroek-Bree	Kinrooi	FS8872	15,9	13,8	3,77	4,17	4,12	0,79
G2	Grootbroek-Bree	Kinrooi	FS8872	21,9	155,1	2,17	4,09	4,31	0,78
GE	Gellikerheide	Lanaken	FS8141	4,6	10,6	1,85	5,19	3,65	0,09
HA	Hallerbos	Halle	ES9218	20,4	25,4	5,07	2,79	3,80	0,21
HB	Heiderbos	Opglabeek	FS8056	6,5	4,4	3,92	5,47	3,59	0,08
HK	Helleketelbos	Poperinge	DS7632	14,5	32,8	4,37	6,58	3,20	0,35
HO	Houthulstbos	Houthulst	DS9746	11,4	35,9	4,55	11,06	3,22	0,62
HW	Heiwijk	Maasmechelen	FS8346	5,9	5,1	3,88	5,06	3,38	0,49
IN	Inslag	Brasschaat	FS0685	3,3	6,8	2,37	4,18	3,89	0,08
K1	Withoefse Heide	Kalmthout	FS0192	2,9	6,8	2,61	10,06	3,42	0,11
K2	Withoefse Heide	Kalmthout	FS0192	3,6	11,2	0,46	6,55	3,45	0,06
KA	Het Kamp	Schilde	FS1183	2,6	15,2	2,11	8,56	3,23	0,07
KB	Kapellebos	Boutersem	FS3137	16,9	31,2	4,64	2,39	3,79	0,19
KK	Kenisberg/ Kruisberg	Diest	FS4754	7,7	6,0	2,31	2,66	3,68	0,06
KL	Kluisbos	Kluisbergen	ES3523	12,8	30,1	3,66	7,87	3,21	0,39
KO	Koolhembos	Puurs	ES9259	23,8	87,7	2,98	1,55	3,86	0,97
LA	Lanklaardebos	Dilsen	FS8653	6,4	3,5	2,78	1,88	3,87	0,15
LE	Het Leen	Waarschoot	ES4056	8,3	28,9	2,58	12,08	3,16	0,30
M1	Meerdaalwoud	Bierbeek	FS2028	16,3	18,0	6,28	2,57	3,80	0,52
M2	Meerdaalwoud	Oud-Heverlee	FS1830	12,7	5,8	3,34	3,27	3,56	0,20
M3	Meerdaalwoud	Oud-Heverlee	FS2030	18,4	10,0	5,31	2,07	3,68	0,67
MU	Muizenbos	Ranst	FS0973	12,9	20,0	5,01	0,36	6,00	0,24
N1	Neigembos	Ninove	ES7529	16,0	24,4	4,74	8,03	3,22	0,25
N2	Neigembos	Ninove	ES7529	16,5	14,3	2,27	5,93	3,31	0,28
NI	Nieuwenhoven	Oostkamp	ES1765	8,9	56,4	4,34	4,39	3,79	0,07
OU	Oude Mombeek	Hasselt	FS6340	32,7	46,2	1,47	0,24	5,80	0,50
P1	Pijnven	Hechtel-Eksel	FS6271	3,9	6,5	2,15	6,62	3,45	0,09
P2	Pijnven	Hechtel-Eksel	FS6372	3,5	6,5	2,22	7,01	3,52	0,08
PA	Parikebos	Brakel	ES5626	19,8	57,6	4,69	0,69	6,54	0,55
PP	Paddepoelebos	Maldegem	ES2976	8,7	20,2	3,84	4,60	3,38	0,61

Abbr.	Forest	Community	UTM	clay (%)	H (%)	LAI	FFW (kg/m²)	pH	N (%)
RA	Raspaillebos	Geraardsbergen	ES6525	15,8	24,2	4,70	6,63	3,80	0,21
RT	RTT-domein	Liedekerke	ES7835	16,8	16,0	3,71	10,83	3,14	0,43
S1	Bos Terrijst	Maarkedal	ES4825	18,2	23,2	5,64	1,26	3,83	0,37
S2	Bos Ter Rijst	Schorisse	ES4825	21,5	25,6	6,33	4,55	3,44	0,45
SE	Sevendonck	Turnhout	FS3482	13,6	38,1	4,07	4,65	3,76	0,27
V1	Vorte Bossen	Ruiselede	ES2657	7,5	10,9	5,46	8,87	3,30	0,26
V2	Vorte Bossen	Ruiselede	ES2657	18,0	29,7	6,02	3,72	3,68	0,43
W1	Wijnendalebos	Ichtegem	ES0257	9,6	18,2	4,26	10,26	3,18	0,18
W2	Wijnendaelebos	Ichtegem	ES0257	19,3	24,5	4,50	8,13	3,65	0,15
W3	Wijnendaelebos	Ichtegem	ES0257	14,3	34,4	2,23	0,01	4,99	0,29
WA	Walenbos	Tielt-Winge	FS3243	12,9	26,9	4,54	2,21	3,28	0,89
Z1	Zoniënwoud	Hoeilaart	ES9922	19,4	17,1	6,76	3,48	3,65	0,36
Z2	Zoniënwoud	Sint-Genesius-Rode	FS0024	22,3	23,0	1,63	3,15	3,64	0,38
Z3	Zoniënwoud	Sint-Genesius-Rode	FS0024	22,3	17,2	4,18	3,37	3,52	0,51
Z4	Zoniënwoud	Hoeilaart	FS0023	22,1	16,4	4,70	3,19	3,74	0,28
ZA	Zandputten	Wichelen	ES6448	11,1	22,8	3,60	7,62	3,40	0,35

in a warm water bath at 80 °C to destroy organic matter. $CaCO_3$ was removed using an acetate buffer solution and addition of a peptisation solution (Vandecasteele et al. 2000). Moisture content was determined after drying soils, sampled during late summer (25/8/99 to 16/9/99), at 105 °C over three days (ISO 11465). Acidity (pH-CaCl2) of the upper soil (Ah or Ap horizont) was measured potentionmetrically using a Janway 3020 AG/AgCl pH electrode in a suspension of 10g dry weight in 100ml 0.01M CaCl2 after two hours shaking. Kjeldahl nitrogen was determined using 0.5g dry weight with CuSO4 and K2SO4 as catalysts using a Vapodest 60 system from Gerhardt (ISO 11261). Leaf Area Index was differentially measured during late summer (25/8/99 to 16/9/99) using a LAI-2000 plant canopy analyser (LiCor 1992). Forest floor weight (kg/m²) was determined after drying at 40°C during one week.

Statistical methods

The stations were classified into clusters according to species composition, using the classification program TWINSPAN (Two-Way INdicator SPecies ANalysis) (Hill 1979). TWINSPAN also yields indicator species characterising the various assemblages. The cutlevels used in this analysis were 1-2-5-20. To check the stability of the TWINSPAN results, the Canonical Correspondence Analysis (CCA) option from the program package CANOCO (Ter Braak 1988) was applied on the log transformed data.

Results

Community analysis

In the present study, 56 forest stands in Flanders were investigated (Fig. 1). The most important environmental parameters are summarised in Table 1. During a pitfall sam-

pling campaign of one year, 21 species of centipedes were found: 8 species belong to the superfamily Geophilomorpha, 2 belong to the superfamily Scolopendromorpha and 11 are included in the superfamily Lithobiomorpha. The result of the TWINSPAN is presented in Table 2. In the first division, the stations from the Campine Region were separated from the other stations. The indicator species for the Campine Region was *Lithobius forficatus* (cutlevel 3) (Fig. 2A) while the indicator species for the other stations was *L. dentatus* (cutlevel 1) (Fig. 2B). In the subsequent division, the remaining stations were divided into those of the Loamy and the Sandy Regions. The indicator species for the Loamy Region was *Cryptops parisi* (cutlevel 2) (Fig. 2C) while the indicator species for Sandy Flanders was *C. hortensis* (cutlevel 1) (Fig. 2D). The three identified clusters could be separated geographically. Only a few stations seemed to be misclassified: Koolhembos (KO), Wijnendaelebos (W3), Muizenbos (MU) and Vorte Bossen (V2) would fit better in the cluster of Sandy Flanders according to their geographic position (Fig. 1). The Canonical Correspondence Analysis (CCA) seemed to justify the division into three assemblages which were separated along the first axis (Eigenvalue 0.25) (Fig. 3). The second axis explained less of the variance (Eigenvalue 0.09). The most important environmental variable as indicated by the CCA was the clay content of the soil which was highest in the Loamy Region, intermediate in Sandy Flanders and minimal in the Campine Region. Due to the higher retention capacity of soils with a higher clay content, humidity and also the Kjeldahl nitrogen were correlated with clay content. The Leaf Area Index was also higher in the Loamy Region if compared with the Campine Region. This difference was probably caused by the difference in forest types: the Loamy Region contained a lot of beech (*Fagus sylvatica*) and oak (*Quercus robur*/*Q. petraea*) forests that have a denser canopy than the selected pine forests (*Pinus sylvestris*/*P. sylvestris spp. nigra*) that constitute the majority of forests in the Campine Region.

Characterisation of the assemblages

The forests of the Campine Region contained the lowest diversity of centipede species. Only *L. forficatus* and *L. calcaratus* were common in most of the stations. The region is characterised by coarse sandy soils which contain a lot of pine plantations.

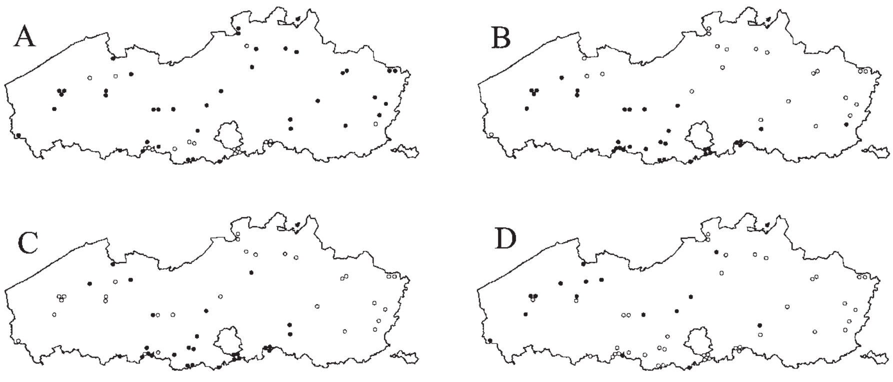

Fig. 2. Distribution of the indicator species *Lithobius forficatus* (A), *L. dentatus* (B), *Cryptops parisi* (C) and *C. hortensis* (D) (● = present; ○ = absent)

Table 2. TWINSPAN table with indicator species in bold (cutlevels: 1 = 1; 2 = 2–4; 3 = 5–19; 4 ≥ 20)

	GNNZZKBRZHKWMMMZBVSEMEAARSBPW E1223B2A4ALA2311U222U112T11A3	BWWHNVZHLIDKP H12OI1AKENRKP	BHKLPHKKSPGGKO EWAA1B21E212OU
Cryptops parisi (Bröleman, 1920)	-3433433434334333-42143-32---	2---1---1---1	--------------
Geophilus proximus (Koch, 1847)	----------------2--1---------	-------------	--------------
Necrophloeophagus flavus (De Geer, 1778)	----------------11-----------	-------------	--------------
Strigamia crassipes (Koch, 1825)	---1-2-222--12322212-22--2---	---1--1------	--------------
Lithobius dentatus (Koch, 1844)	333334444432-32434344-43444344	3444444------	--------------
Brachygeophilus truncorum (Bergsoë & Meinert, 1886)	--13--13221-1333--122---2211-	2124132421111	---------3----
Lithobius agilis (Koch, 1847)	2----3-3--------2--1-2--3211-	------3------	-2------------
Lithobius macilentus (Koch, 1862)	13-223232-1-11213133242333333	1-22-2241-3--	----------33-1
Lithobius tricuspis (Meinert, 1872)	2-21-1222-----1------2--3---1	2111---3-----	-------1------
Cryptops hortensis (Leach, 1814)	---------2---------------1---	3322123342313	------------1-
Geophilus carpophagus (Leach, 1814)	----------------------------1	---1-2----21-	--------------
Haplophilus subterraneus (Shaw, 1789)	-----------------------------	--1----------	--------------
Lithobius microps (Meinert, 1868)	-------1----424-3324444413-2-	-1--221-11---	3-31--1------3
Lithobius muticus (Koch, 1847)	-11--------------------42433341	-1----3------	---1------1-12
Strigamia acuminata (Leach, 1814)	--1-32-2------1-222------1333	-----2-31-1--	----------122-
Schendyla nemorensis (Koch, 1837)	21132---1--1--1-2121--2223---	1-3111233221-	1123-1--------
Lithobius crassipes (Koch, 1862)	-1--2--1--2-123--43--43343--2	233224-33---2	2414------4334
Lithobius melanops (Newport, 1845)	----------------2------------	-------------	-------------1
Lamyctes fulvicornis (Meinert, 1868)	-----------------------------	-------------	--------3-3---
Lithobius calcaratus (Koch, 1844)	-1-------1--2-------22--22-11	-2132133122-1	4344343233---1
Lithobius forficatus (Linnaeus, 1758)	-----1---111----241123111--22	2242-2221--22	33343444423334
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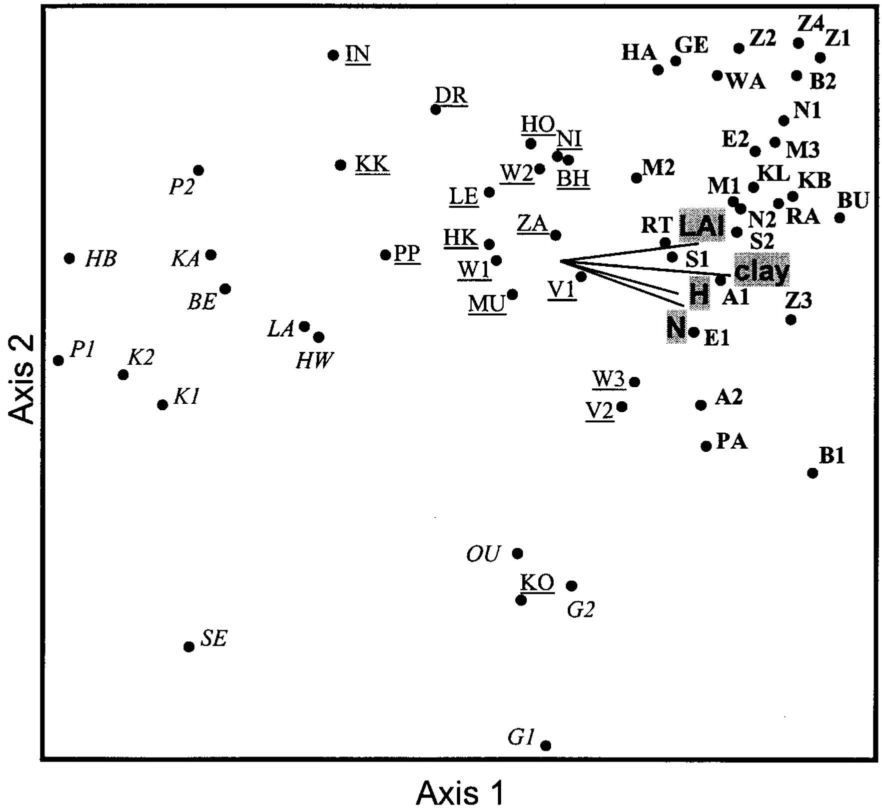

Fig. 3. Biplot of the sample scores and the environmental variables (LAI = Leaf Area Index; H = humidity; N = Kjeldahl nitrogen) with indication of the three clusters: Campine Region italics, Sandy Flanders underlined and Loamy Region bold

Sandy Flanders has a lot of oak and beech forests. *Cryptops hortensis* is the indicator species for this region but also *Brachygeophilus truncorum, Schendyla nemorensis, Lithobius crassipes, L. calcaratus* and *L. forficatus* are often present. *Cryptops parisi* and *Lithobius dentatus* are the most characteristic species but also *Brachygeophilus truncorum, Strigamia crassipes, L. macilentus* and *L. microps* are often present.

Discussion

In the forests of Flanders, 21 out of 29 species reported for Belgium (Lock, submitted) were found which is quite a big portion of the centipede species. However, with pitfalls, only the epigeic species can be captured. According to Blower (1955) large lithobiids prefer the litter layer whereas small lithobiids and geophilomorphids occur mostly in the deeper layers. The blind geophilomorphs with their long thin bodies and many legs are adapted to life in the soil where they live on oligochaetes. Therefore, the geophilomorphids are probably under represented in the present study.

In many forest ecosystems, the same structure in species distribution of lithobiids is found: two dominant species, with other species rarely occurring (Albert 1979). In the forests of Flanders, this structure of species distribution could not be found: the number of abundant species of lithobiid species ranged from 0 to 5 and there was only a small portion with two common lithobiids. However, some species seemed to avoid each other: *Cryptops hortensis* and *C. parisi, Strigamia crassipes* and *S. acuminata, Lithobius dentatus* and *L. forficatus*. The difference between the habitat preferences of the latter couple of species could be related to the forest type: *L. forficatus* occurs significantly more often in coniferous than in deciduous forests (Andersson 1985) while *L. dentatus* is characterised as a deciduous forest species which does not occur in coniferous forests (Verhoeff 1937; Albert 1978).

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